

APPENDIX D. ACOUSTIC DOPPLER CURRENT PROFILER DATA

Appendix D illustrates measurements of spatial and temporal variation in currents for an offshore shoal located near Sand Resource Areas B1 and B2 for the late May and early September 2001 surveys. The data acquisition program was designed to measure spatial and temporal variations in the current regime with the intent of understanding flow field dynamics driving sediment transport. Data are presented as vector maps, showing the speed and direction of flow vectors displayed as arrows. The length of each arrow represents speed, and the orientation of the arrow represents direction.

A general discussion of instrumentation and field methods used to collect data is presented below. Discussion of results was presented in the main body of the report in Section 5, Circulation and Sediment Transport Dynamics.

Survey Equipment

An Acoustic Doppler Current Profiler (ADCP) is capable of high-resolution measurements of spatial variation in current flow beneath the instrument transducer. When mounted to a moving platform, such as a small vessel, this method provides a detailed view of regional current patterns. Repeating transect cycles at regular time intervals throughout a complete tidal cycle offers an unparalleled determination of temporal variation in current structure.

An ADCP measures currents using individual acoustic pulses emitted from four angled (at 20 deg from vertical) transducers in the instrument. The instrument listens for backscattered echoes from discrete depth layers in the water column, with returned echoes, reflected from ambient sound scatters (plankton, debris, sediment, etc.), compared in the frequency domain to the original emitted pulse. The change in frequency (doppler shift) between the emitted and reflected pulse is directly proportional to the speed of water normal to the individual beam. For example, an echo of lower frequency indicates water moving away from the transducer while an echo of higher frequency indicates water moving toward the transducer. By combining the doppler velocity components for at least three of the four directional beams, the current velocities can be transformed to an orthogonal earth coordinate system in terms of east, north, and vertical components of current velocity.

Vertical resolution is gained using a technique called 'range-gating'. Returning pulses are divided into discrete 'bins' based on discrete time intervals following emission of the original pulse. With knowledge of the speed of sound, discrete time intervals reflect the range (or depth) of each discrete bin from the transducer face.

Collection of accurate current data with an ADCP requires removal of transducer speed (mounted to the vessel) from the estimates of current velocity. This is performed by 'bottom tracking' or using the doppler shift to measure simultaneously the velocity of the transducer relative to the bottom. Bottom tracking allows the ADCP to record absolute versus relative velocities beneath the transducer. In addition, the accuracy of current measurements can be compromised by random errors (or noise) inherent to this technique.

Improvements in the accuracy of each measurement are achieved by averaging several individual pulses. These averaged results are termed 'ensembles'; the more pings used in the average, the lower the standard deviation of the random error.

For this study, the standard deviation (or accuracy) of current estimates (resulting from an ensemble average of 5 individual pulses) was approximately 1.3 cm/sec. Each ensemble took about 4 sec to collect. Averaging parameters resulted in a horizontal resolution of approximately 10 to 12 m along the transect line. For example, a transect line was about 11 km long, resulting in approximately 1,000 independent velocity profiles per transect. The vertical resolution was set to 0.5 m, or one velocity observation per 0.5 m of water depth. The first measurement bin was centered 1.5 m from the surface, allowing for transducer draft and an appropriate blanking distance between the transducer and the first measurement. The transducer draft was 50 cm below the surface; the blanking distance was set to 0.5 m.

Position information was collected using a differential global positioning system (DGPS) linked to HYPACK®, an integrated navigation software package running on a personal computer. Position data were recorded in Universal Transverse Mercator (UTM) coordinates and the North American Datum of 1983 (NAD83). Position updates were available every 2 seconds, although brief interruptions of position data were experienced when thunderstorms were in the area. These brief losses of position data (less than 10 seconds) did not compromise results. Raw position data also were sent to the ADCP laptop to assist in verifying clock synchronization between the DGPS and ADCP.

Data Processing and Quality

The surveys resulted in two types of data: current velocity and vessel position. ADCP data for a single transect consisted of velocity components at every depth bin for every ensemble. In addition, raw ADCP (binary) files also included ancillary data such as correlation magnitudes, echo amplitudes, percent good pings, and error velocities (among others). These data can be used to recalculate velocities and assure quality of results. Furthermore, each ensemble includes header information, such as ensemble number, ensemble time, and surface water temperature. Position data were recorded as time-northing-easting within HYPACK®. The northing-easting pairs were referenced to UTM NAD83.

Raw ADCP data were converted to ASCII files using manufacturer software. For this program, the two earth-referenced velocity components (V_{east} and V_{north}) were reported, as well as current speed, current direction, and error velocity. The conversion process outputs each ensemble profile as a function of depth (e.g., V_{east} versus depth, V_{north} versus depth). The entire data file represents each ensemble profile along the transect. Approximately 1,000 individual profiles were obtained per transect. Eight transects were completed each survey day, resulting in approximately 8,000 independent current profiles throughout the study area per day.

Ensemble profiles must be merged with position data to assign a unique x-y pair to every ensemble. This merging operation was done using time and DGPS position as the common link between HYPACK® and ADCP data files. By searching for a unique position at a specific time for each of the data sets, an accurate x-y location was assigned to each ensemble.

The error velocity column is an indicator of data quality. Error velocities typically are higher in bottom bins than in mid-water bins. Bottom bins can become contaminated by high amplitude echoes reflected near the ocean bottom and should be discounted. Plots of

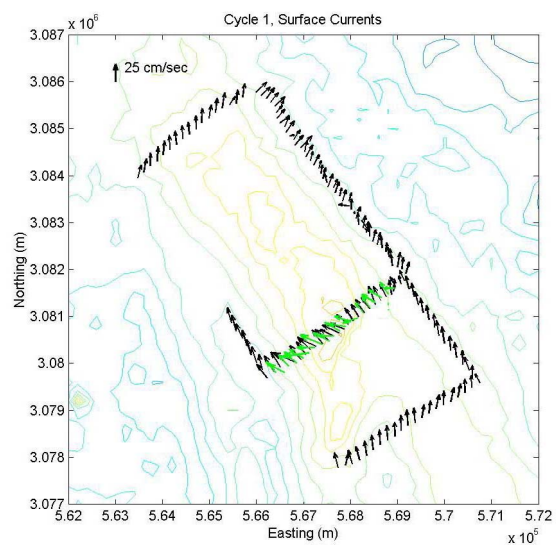
error velocity showed that data quality was high for Cycles 1 through 5 in May and all survey cycles in September. However, there do exist portions in each data file that tend to have higher noise levels than others. These elevated noise levels can result from two sources: measurement noise and/or environmental noise. Measurement noise can be due to unwanted vessel motions (for example vessel pitch and roll in the waves), cavitation near the transducer head, or contamination due to vessel wake. It is difficult in practice to distinguish between noise sources. Plots of error velocity are one method of assuring the measurements reflect actual flow conditions and not unwanted platform motions.

Data Presentation

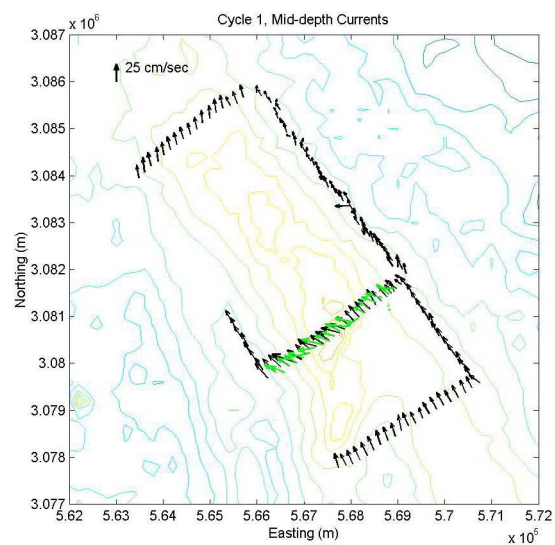
Flow vectors are presented as vector maps for the survey area. Vector maps represent spatially-averaged current velocities at specific locations within the survey domain. Velocity profiles were separated into near-surface, mid-depth, and near-bottom layers and grouped within discrete 'neighborhoods' along transect paths. Vectors corresponding to a single survey cycle (8 transects) were then displayed on an area map. These vector maps were produced for each of the three depth layers and for each of the six survey cycles. Each survey cycle took approximately 4 hours to complete. A series of plots show temporal variation in horizontal and vertical currents during the survey.

Results of the May 29 and 30, 2001 survey over an offshore shoal near Sand Resource Areas B1 and B2 are presented in the first six figures. Figure D-1 presents the surface layer, mid-depth layer, and bottom layer vectors for the first transect cycle that occurred from 2000 hours to 0040 hours. Figure D-2 represents the same depth layers for the second transect cycle that occurred from 0040 hours to 0430 hours. Figure D-3 represents the third transect cycle from 0430 hours to 0800 hours. Figure D-4 represents the fourth transect cycle from 0800 hours to 1200 hours. Figure D-5 represents the fifth transect cycle from 1200 hours to 1530 hours. Figure D-6 represents the sixth transect cycle from 1530 hours to 1820 hours.

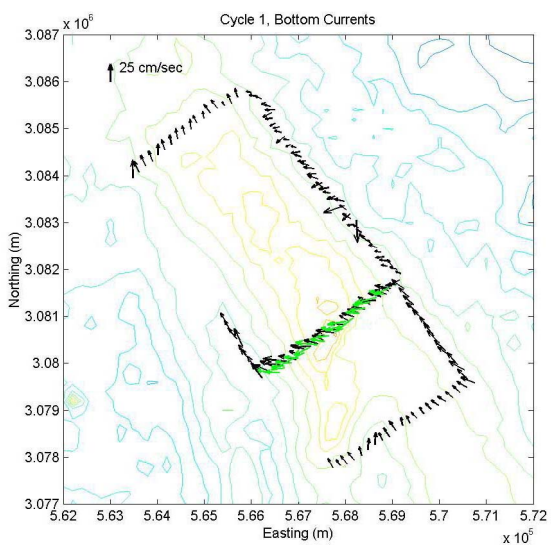
Results from the September 4 and 5, 2001 survey are presented in Figures D-7 through D-12 in the same format.



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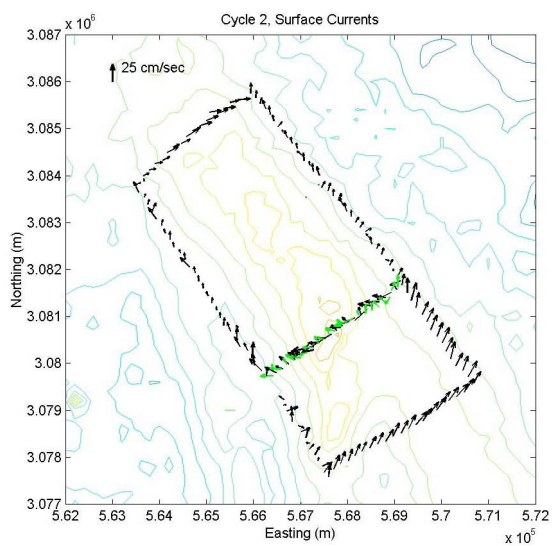


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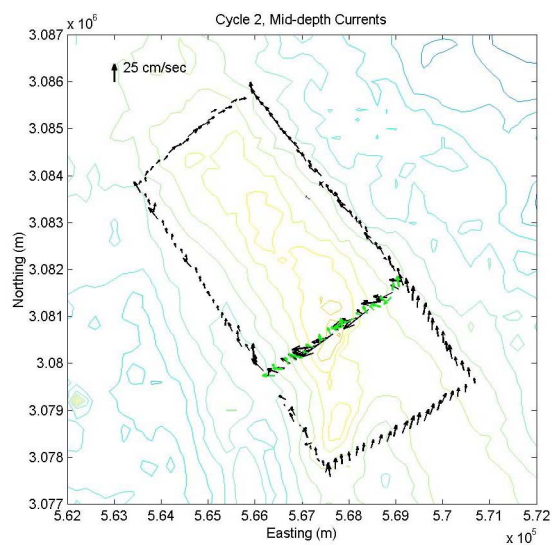


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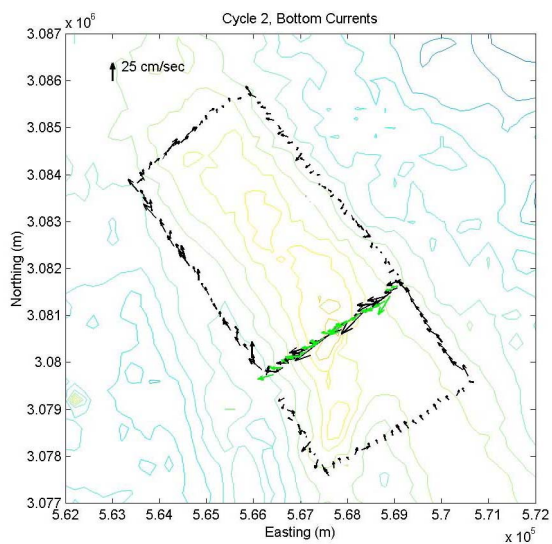
Figure D-1. ADCP survey transect Cycle 1 for surface, middle and bottom, May 29, 2001, 0000 hours to May 30, 2001, 0040 hours.



Surface Layer

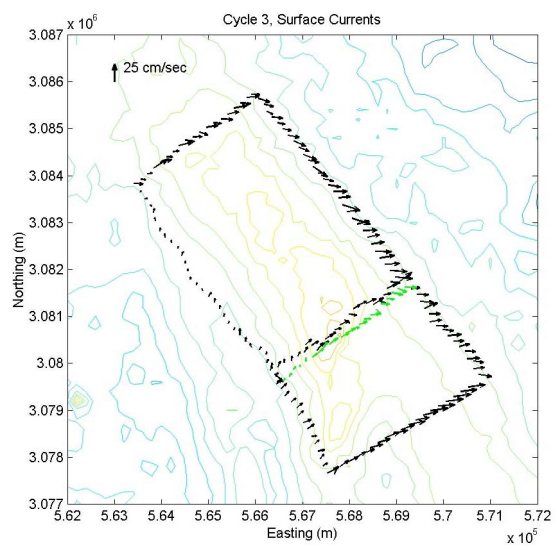


Middle Layer

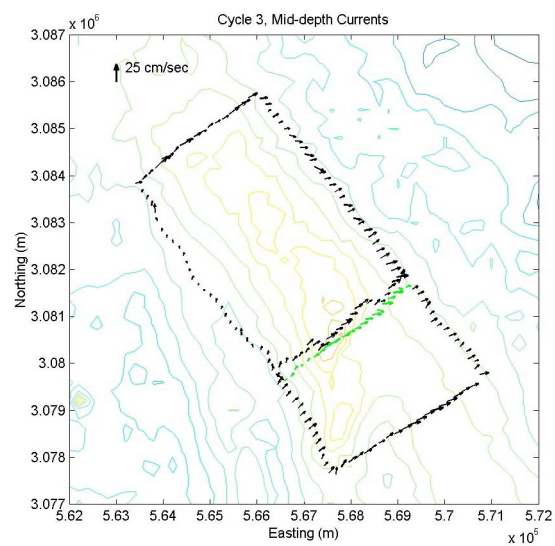


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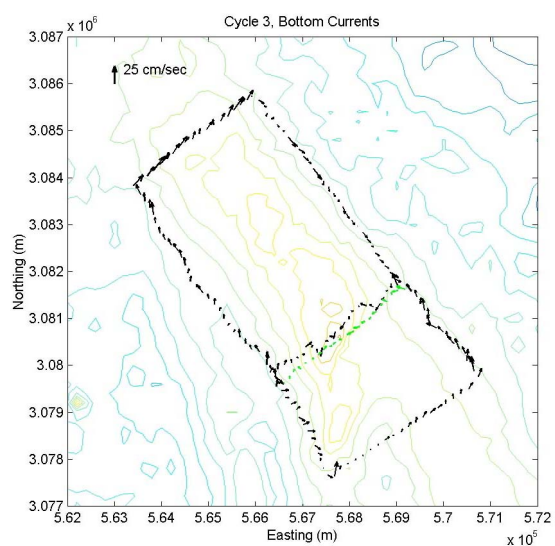
Figure D-2. ADCP survey transect Cycle 2 for surface, middle and bottom, May 30, 2001, 0040 to 0430 hours.



Surface Layer

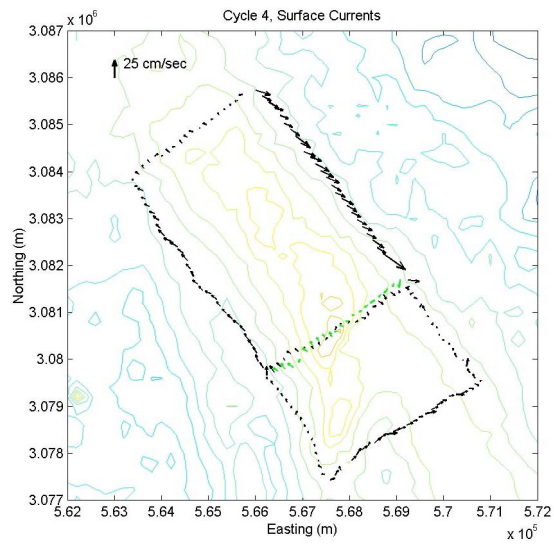


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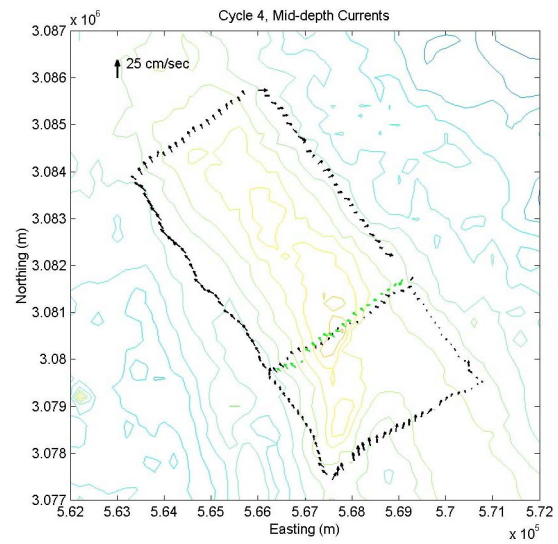


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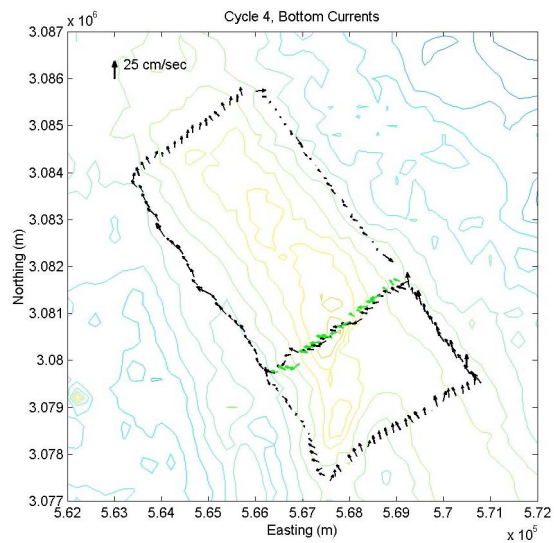
Figure D-3. ADCP survey transect Cycle 3 for surface, middle and bottom, May 30, 2001, 0430 to 0800hours.



Surface Layer

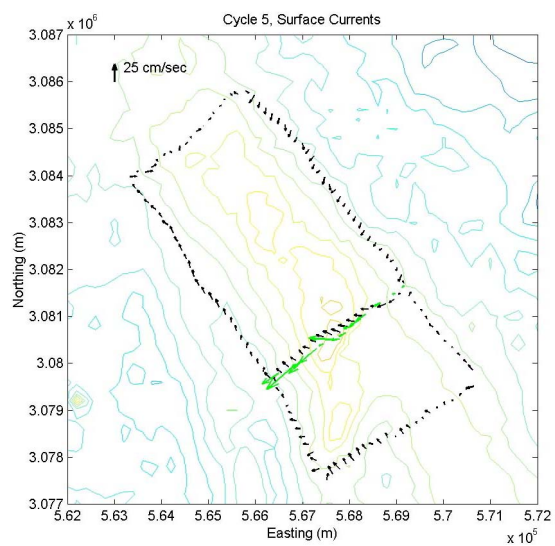


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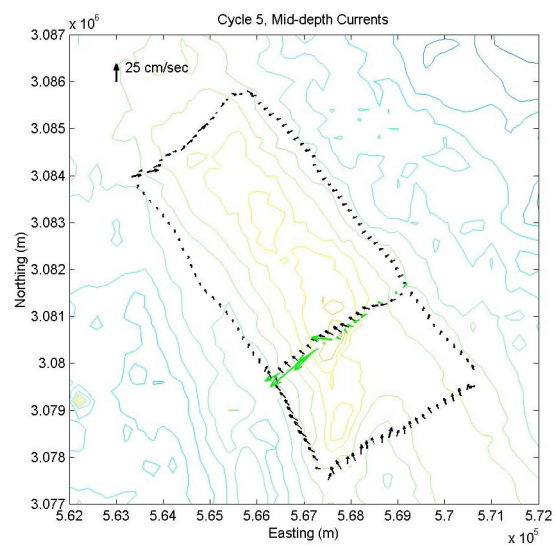


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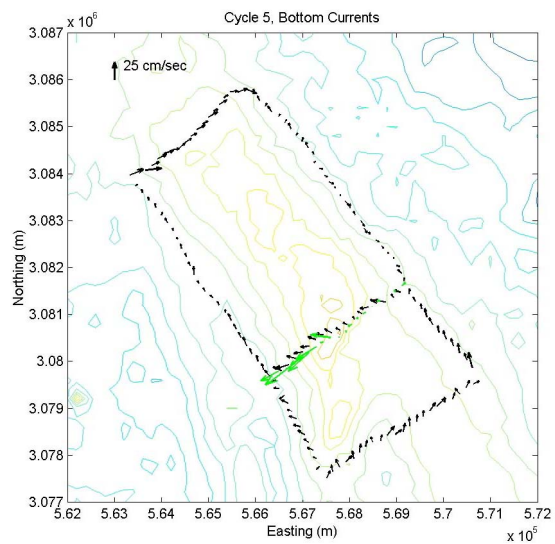
Figure D-4. ADCP survey transect Cycle 4 for surface, middle and bottom, May 30, 2001, 0800 to 1200 hours.



Surface Layer

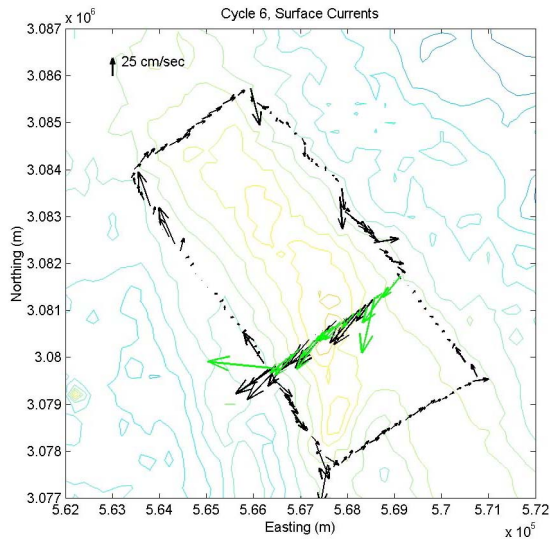


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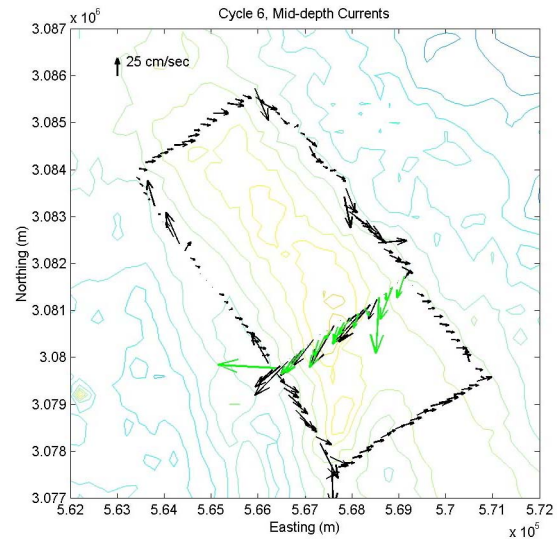


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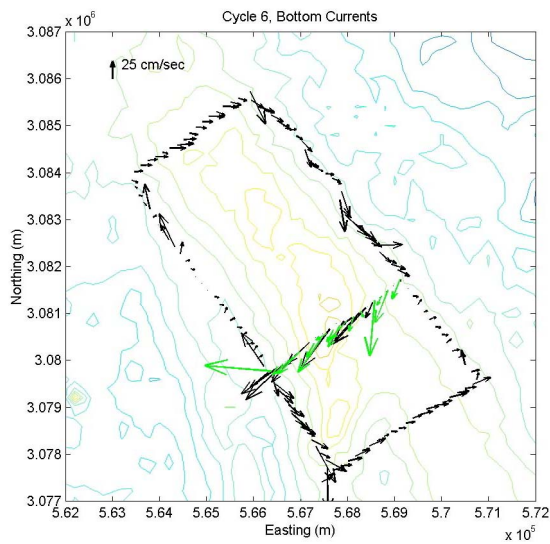
Figure D-5. ADCP survey transect Cycle 5 for surface, middle and bottom, May 30, 2001, 1200 to 1530 hours.



Surface Layer

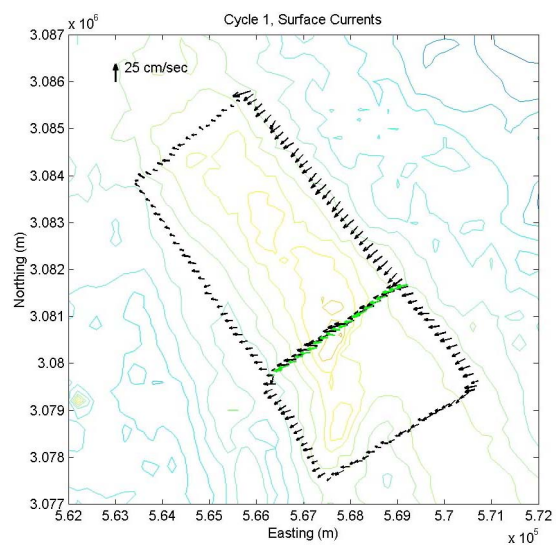


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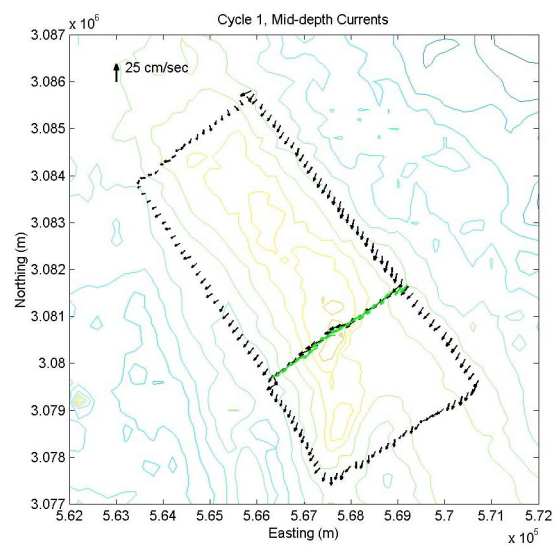


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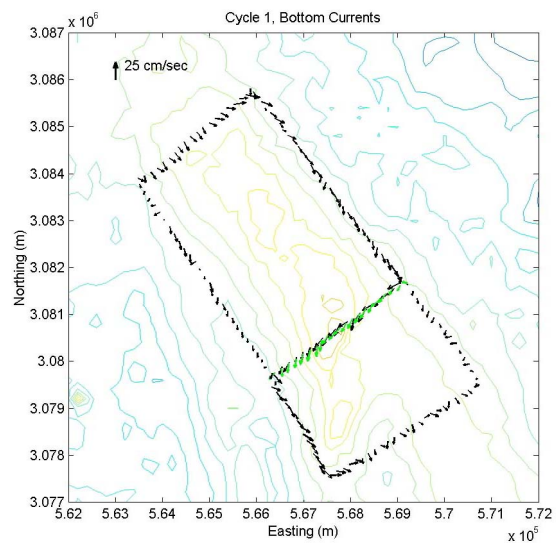
Figure D-6. ADCP survey transect Cycle 6 for surface, middle and bottom, May 30, 2001, 1530 to 1820 hours.



Surface Layer

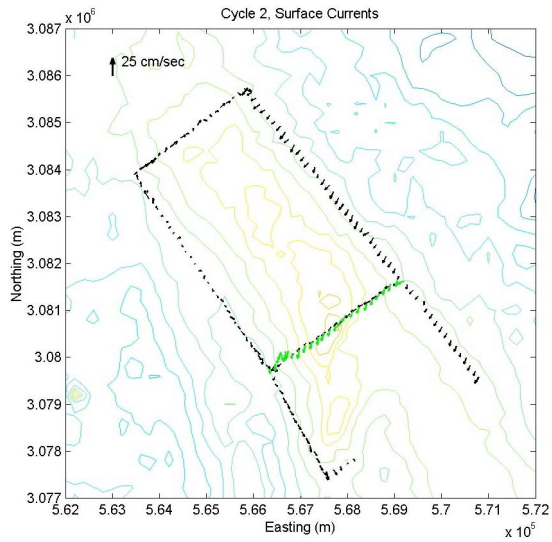


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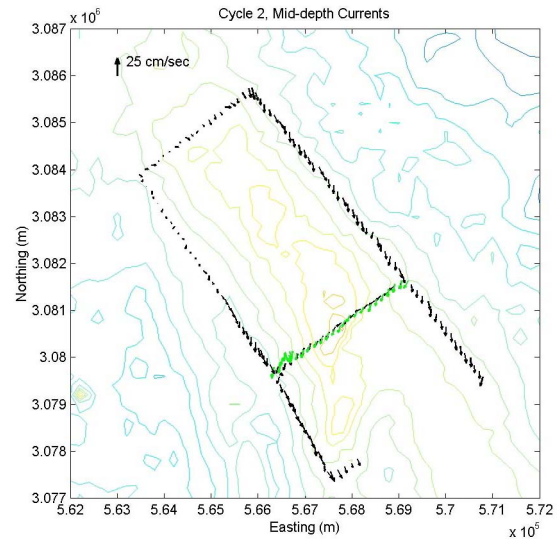


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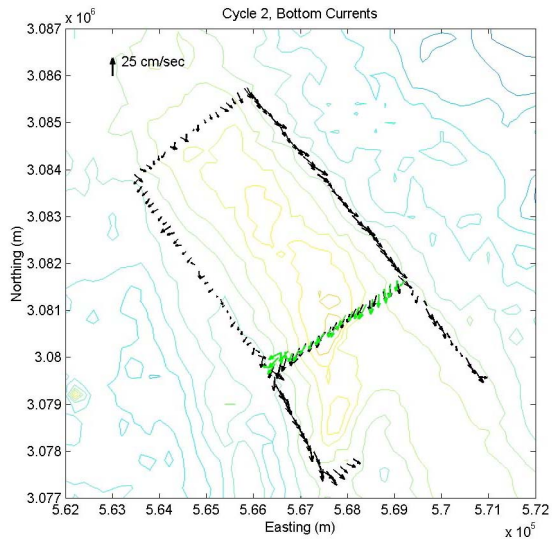
Figure D-7. ADCP survey transect Cycle 1 for surface, middle and bottom, September 4, 2001, 1900 to 2230 hours.



Surface Layer

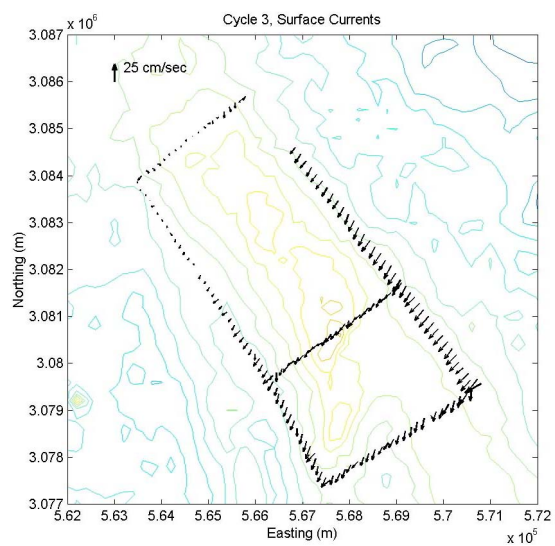


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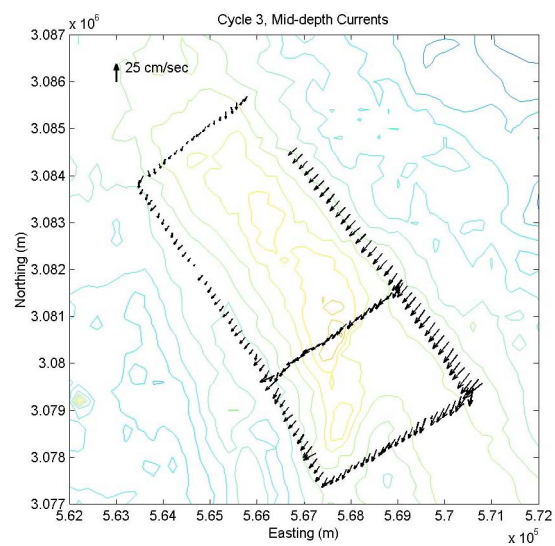


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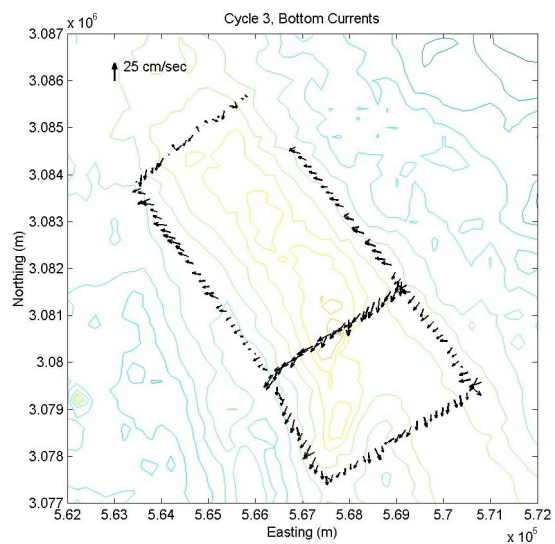
Figure D-8. ADCP survey transect Cycle 2 for surface, middle and bottom, September 4, 2001, 2230 to September 5, 2001, 0220 hours.



Surface Layer

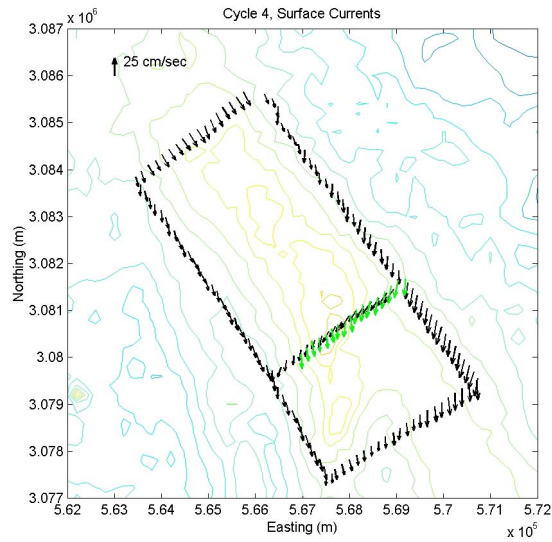


Middle Layer

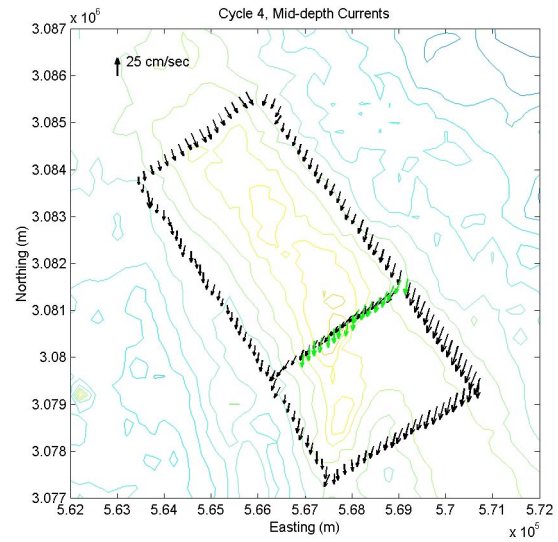


Bottom Layer

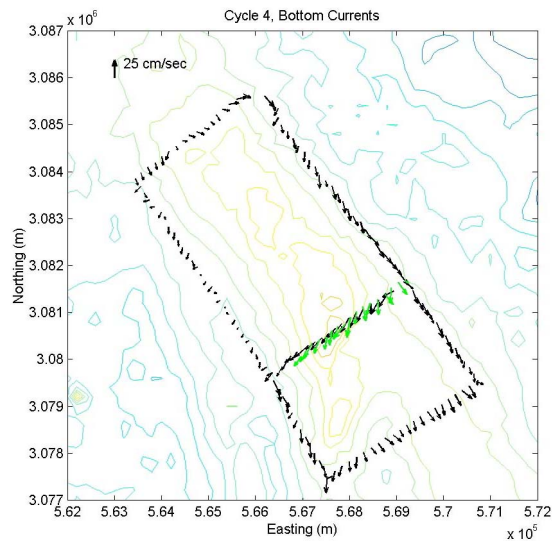
Figure D-9. ADCP survey transect Cycle 3 for surface, middle and bottom, September 5, 2001, 0220 to 0620 hours.



Surface Layer

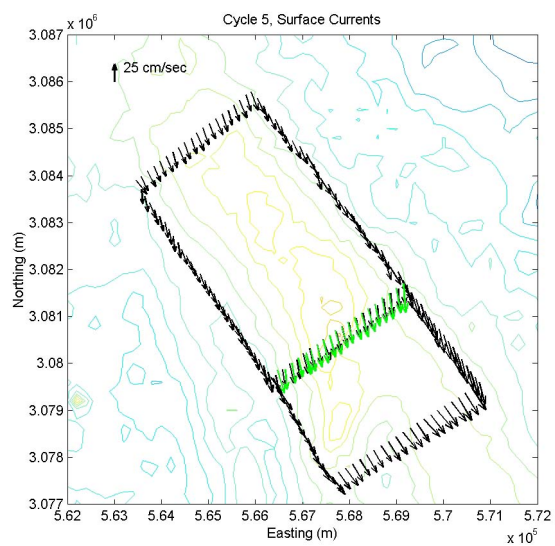


Middle Layer

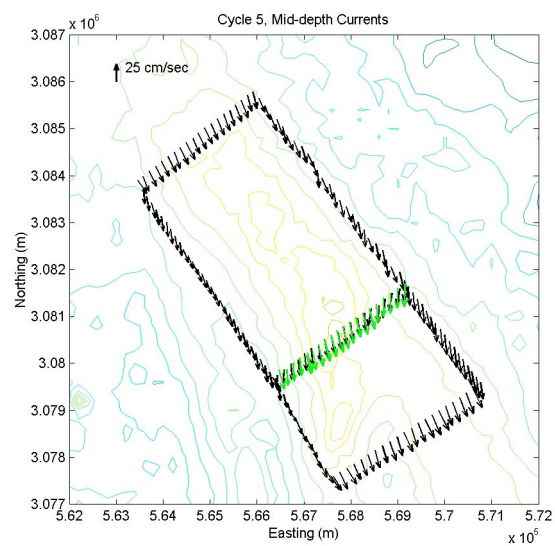


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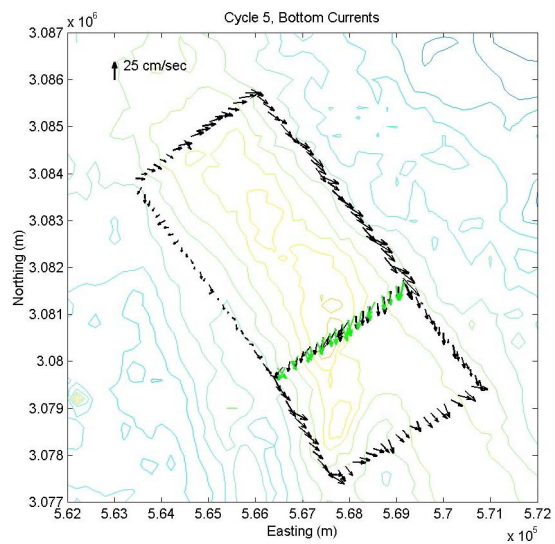
Figure D-10. ADCP survey transect Cycle 4 for surface, middle and bottom, September 5, 2001, 0800 to 1200 hours.



Surface Layer

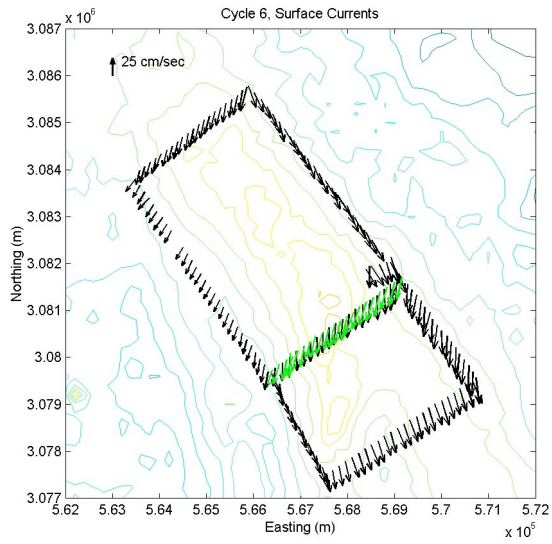


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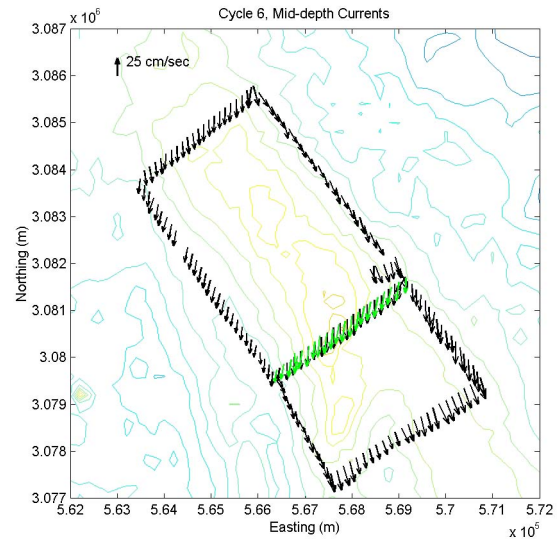


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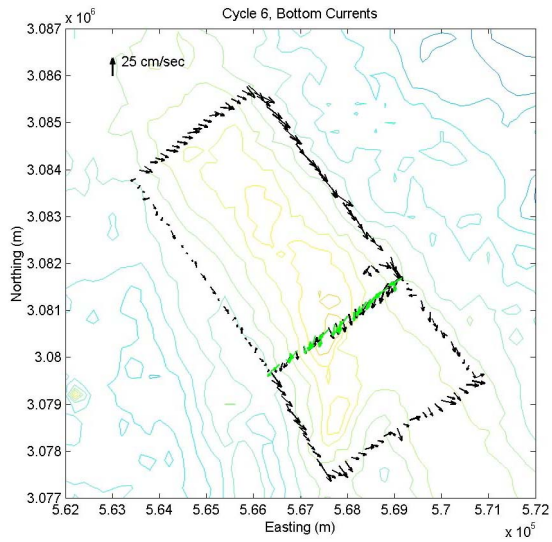
Figure D-11. ADCP survey transect Cycle 5 for surface, middle and bottom, September 5, 2001, 1200 to 1500 hours.



Surface Layer



Middle Layer



Bottom Layer

Figure D-12. ADCP survey transect Cycle 6 for surface, middle and bottom, September 5, 2001, 1500 to 1830 hours.

